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1859-1951

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Box Patent Application
Commissioner for Patents
Washington, DC 20231

Presented for filing is a new divisional patent application of:

Applicant: MELVIN GABLE, ROY LEWIS AND WILLIAM CALDWELL

Title: DIGITAL VIDEO AND DATA RECORDER

The prior application is assigned of record to Indigita Corporation,
a California corporation, by virtue of an assignment submitted to the Patent and
Trademark Office and recorded on November 17, 1997 at Reel/Frame 8819/0228.

Enclosed are the following papers, including those required to receive a filing date
under 37 CFR 1.53(b):

	<u>Pages</u>
Specification	18
Claims	4
Abstract	1
Declaration	2
Drawing(s)	3

Enclosures:

- Form PTO-1449, 2 pages, and Form PTO-892, 1 page, listing documents
cited in the parent application(s). Please confirm that these have been
considered in this application by returning a copy of the Form PTO-1449

CERTIFICATE OF MAILING BY EXPRESS MAIL

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September 19, 2000

Page 2

with the examiner's initials. Per Rule 97(d) copies of those documents are not provided.

- Small entity statement from patent application. Status as a small entity is still desired and proper.
- Postcard.

This application is a divisional (and claims the benefit of priority under 35 USC 120) of U.S. application serial no. 08/858,084, filed May 16, 1997. The disclosure of the prior application is considered part of (and is incorporated by reference in) the disclosure of this application.

Basic filing fee	\$345
Total claims in excess of 20 times \$9	\$0
Independent claims in excess of 3 times \$39	\$0
Fee for multiple dependent claims	\$0
Total filing fee:	\$345

A check for the filing fee is enclosed. Please apply any other required fees or any credits to deposit account 06-1050, referencing the attorney docket number shown above.


If this application is found to be incomplete, or if a telephone conference would otherwise be helpful, please call the undersigned at (858) 678-5070.

Kindly acknowledge receipt of this application by returning the enclosed postcard.

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Respectfully submitted,


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Applicant or Patentee: Melvin Gable, et al.

ATTORNEY DOCKET NO. 08407/005001

Serial or Patent No.:

Filed or Issued: 5/16/97

For: DIGITAL VIDEO AND DATA RECORDER

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) and 1.27(c)) - SMALL BUSINESS CONCERN

I hereby declare that I am

☐ the owner of the small business concern identified below:

☒ an official of the small business concern empowered to act on behalf of the concern identified below:

Name of Small Business Concern: INDIGITA CORPORATION

Address of Small Business Concern: 17320 RED HILL AVENUE, SUITE 200, IRVINE, CA 92614

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled DIGITAL VIDEO AND DATA RECORDER by inventor(s) MELVIN GABLE, ROY LEWIS, WILLIAM CALDWELL described in

☐ the specification filed herewith.

☒ application serial no. 08/858,084 filed 5/16/97.

☐ patent no. , issued .

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e). NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

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I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent on which this verified statement is directed.

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Title: EXECUTIVE VICE PRESIDENT

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Signature: *Irwin Kwatek*

Date: June 23, 1997

1990-1991		1991-1992		1992-1993		1993-1994		1994-1995		1995-1996		1996-1997		1997-1998		1998-1999		1999-2000		2000-2001		2001-2002		2002-2003		2003-2004		2004-2005		2005-2006		2006-2007		2007-2008		2008-2009		2009-2010		2010-2011		2011-2012		2012-2013		2013-2014		2014-2015		2015-2016		2016-2017		2017-2018		2018-2019		2019-2020		2020-2021		2021-2022		2022-2023		2023-2024		2024-2025		2025-2026		2026-2027		2027-2028		2028-2029		2029-2030		2030-2031		2031-2032		2032-2033		2033-2034		2034-2035		2035-2036		2036-2037		2037-2038		2038-2039		2039-2040		2040-2041		2041-2042		2042-2043		2043-2044		2044-2045		2045-2046		2046-2047		2047-2048		2048-2049		2049-2050		2050-2051		2051-2052		2052-2053		2053-2054		2054-2055		2055-2056		2056-2057		2057-2058		2058-2059		2059-2060		2060-2061		2061-2062		2062-2063		2063-2064		2064-2065		2065-2066		2066-2067		2067-2068		2068-2069		2069-2070		2070-2071		2071-2072		2072-2073		2073-2074		2074-2075		2075-2076		2076-2077		2077-2078		2078-2079		2079-2080		2080-2081		2081-2082		2082-2083		2083-2084		2084-2085		2085-2086		2086-2087		2087-2088		2088-2089		2089-2090		2090-2091		2091-2092		2092-2093		2093-2094		2094-2095		2095-2096		2096-2097		2097-2098		2098-2099		2099-2100		2100-2101		2101-2102		2102-2103		2103-2104		2104-2105		2105-2106		2106-2107		2107-2108		2108-2109		2109-2110		2110-2111		2111-2112		2112-2113		2113-2114		2114-2115		2115-2116		2116-2117		2117-2118		2118-2119		2119-2120		2120-2121		2121-2122		2122-2123		2123-2124		2124-2125		2125-2126		2126-2127		2127-2128		2128-2129		2129-2130		2130-2131		2131-2132		2132-2133		2133-2134		2134-2135		2135-2136		2136-2137		2137-2138		2138-2139		2139-2140		2140-2141		2141-2142		2142-2143		2143-2144		2144-2145		2145-2146		2146-2147		2147-2148		2148-2149		2149-2150		2150-2151		2151-2152		2152-2153		2153-2154		2154-2155		2155-2156		2156-2157		2157-2158		2158-2159		2159-2160		2160-2161		2161-2162		2162-2163		2163-2164		2164-2165		2165-2166		2166-2167		2167-2168		2168-2169		2169-2170		2170-2171		2171-2172		2172-2173		2173-2174		2174-2175		2175-2176		2176-2177		2177-2178		2178-2179		2179-2180		2180-2181		2181-2182		2182-2183		2183-2184		2184-2185		2185-2186		2186-2187		2187-2188		2188-2189		2189-2190		2190-2191		2191-2192		2192-2193		2193-2194		2194-2195		2195-2196		2196-2197		2197-2198		2198-2199		2199-2200		2200-2201		2201-2202		2202-2203		2203-2204		2204-2205		2205-2206		2206-2207		2207-2208		2208-2209		2209-2210		2210-2211		2211-2212		2212-2213		2213-2214		2214-2215		2215-2216		2216-2217	
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of

DIGITAL VIDEO AND DATA RECORDER

20231. 

EXPRESS MAIL NO. EL558602921US

DIGITAL VIDEO AND DATA RECORDER

REFERENCE TO RELATED APPLICATION

This application is a divisional of U.S. Application Serial No. 08/858,084, filed May 16, 1997 (pending).

5 BACKGROUND OF THE INVENTION

1. *Field of the Invention*

This invention relates to electronic recording and playback devices, and more particular to electronic recording and playback devices for recording and playing back compressed digital video and audio data.

10 2. *Description of Related Art*

A number of approaches exist for recording audiovideo sequences. Analog video tape solutions, such as VHS and Beta brand video cassette recorders, use a frame-to-frame recording process where each video frame is recorded on individual analog tracks at a fixed frame rate of 30 Hz for NTSC or 25 Hz for PAL. Each frame comprises two fields at 60 Hz for NTSC encoded video and two fields at 50 Hz for PAL encoded video. This analog method of recording allows for random access to each frame in the video sequence.

The Moving Picture Experts Group (MPEG) has promulgated widely accepted international standards for compression, decompression, and synchronization of digital video and audio signals. In particular, MPEG has defined a set of standards for video compression algorithms commonly used by broadcasters and studios for recording and broadcasting digital encoded video. The video and audio specifications give the syntax and semantics of encoded video and audio bitstreams necessary for communicating

compressed digital video as well as for storing such video on media in a standard format. The MPEG1 standard is officially described in ISO/IEC 11172 and the MPEG2 standard in ISO/IEC 13818.

More particularly, the MPEG standards define how elementary streams of encoded digital audio and video data are multiplexed and converted to an MPEG format, which may then be communicated on a channel in some channel-specific format for direct replay or for storage before channel transmission and replay. Within a channel is a Channel Stream, which could be a System Stream in MPEG1, and either a Program Stream or Transport Stream in MPEG2.

A processed Channel Stream is demultiplexed, and the elementary streams produced are input into Video and Audio Decoders, the outputs of which are decoded video and audio signals. FIGURE 1 is a block diagram of a prior art MPEG decoder, showing the application of a Channel Stream of MPEG encoded data to a channel specific decoder 1 which decodes the channel-specific transmission format. The output of the channel specific decoder 1 is coupled to a system decoder 2, which demultiplexes the digital audio and video data. Video data is further applied to a video decoder 3, and audio data is further applied to an audio decoder 4. There is a flow of timing information among the several decoders, controlled by a clock controller 5. All elementary data streams are decoded and presented with time synchronization.

The MPEG2 standard specifically defines three types of video pictures or frames: intra-coded, predicted, and bi-directional. Intra-coded or I-frames are coded using only information present in an image frame itself. I-frames provide random access points into a compressed video data stream. I-frames use only transform coding (discrete cosine transform, or "DCT"), and therefore provide moderate compression. Predicted or P-frames are coded based in part on information within the nearest previous I or P frame, using a technique called forward prediction. P-frames provide more compression than I-frames and serve as a reference for bi-directional or B-frames and for later P-frames. P-

frames can propagate coding errors since P-frames are generally predicted from previous P-frames. B-frames are frames that use both past and future frames as a reference. Bi-directional frames provide the most compression of the three frame types and do not propagate errors because they are never used as a reference. The MPEG2 algorithm allows the encoder to choose the frequency and location of I-frames, and thus MPEG recordings have a non-fixed frame rate. This characteristic makes it difficult to have random accessibility to a scene cut in a video sequence which is between I-frames. To achieve random access, a video sequence must start at an I-frame.

It would be desirable to be able to record and playback encoded video and audio that is digitally encoded at a non-fixed frame rate. However, two problems exist when attempting to perform such recording: a "channel changing" problem arising from attempts to record video sequences from two or more independent MPEG data streams, and a "pause and resume" problem arising from attempts to record a single MPEG video sequence while occasionally pausing such recording.

The MPEG standards provide a timing mechanism that ensures synchronization of audio and video. The MPEG1 standard defines two parameters used by an MPEG decoder: a system clock reference (SCR) and a presentation time stamp (PTS). The MPEG2 standard adds a program clock reference (PCR) that is equivalent to the SCR. Both the SCR and PCR have extensions in order to achieve a resolution of 27 MHz (the term "SCR/PCR" will be used herein to denote either clock reference). The SCR/PCR is a snapshot of the encoder system clock. The SCR/PCRs used by an MPEG video decoder 3 and audio decoder 4 must have approximately the same value for proper synchronization. The video decoder 3 and audio decoder 4 update their internal clocks using the SCR/PCR value sent by the system decoder 2. Each decoded video picture and decoded audio time sequence (both are also referred to as "presentation units") has a PTS associated with it. The PTS represents the time at which the video picture is to be displayed or the starting playback time for the audio time sequence.

If video sequences from two or more independent streams are spliced together, the SCR/PCR values will be different for each of the streams. Hence, the PTS for the video and audio will become unlocked from the original SCR/PCR clock. Conventionally, the video decoder 3 and audio decoder 4 will either discard the affected presentation units if
5 their PTS is earlier (has a smaller value) than the current SCR/PCR, or repeat the affected presentation units if their PTS is later (has a larger value) than the current SCR/PCR. In either case, the output is visually and audibly affected by the clock mismatch.

When pausing during the recording of an MPEG video sequence, mixing of streams having B-frames or P-frames will result in improper decoding. Streams from the different
10 recording sessions must be separated to avoid generation of predicted picture frames using inappropriate picture references (*i.e.*, I or P frames from a different video sequence). This problem also occurs when splicing two independent sequences.

Digital Video (DV) is a relatively new video compression format standard. DV does not contain the bi-directional and predictive frames of MPEG2. Therefore, session boundaries
15 can be at any frame. DV produces a fixed data rate of approximately 25 Mbps utilizing a fixed 5:1 compression based on 4:1:1 YUV video sampling. DV compression relies on discrete cosine transforms like MPEG, but adds the enhancement of field interpolation on low-motion scenes. When recording digital video data, such information is interleaved across the recording medium (*e.g.*, tape) within a single frame. This technique is used to
20 reduce dropouts and other tape artifacts commonly found in analog track formats. Although DV provides random access, it does not have the ability to record more highly compressed MPEG data streams, which include P-frames or B-frames.

Accordingly, the inventors have determined that it would be desirable to be able to intermittently record and pause MPEG video sequences, to splice independent sequences,
25 and to provide random access to recorded video sequences without the problems of current technology. The present invention provides a method and apparatus for accomplishing this goal.

SUMMARY OF THE INVENTION

5 The invention generally relates to the recording of digital video and audio data, and more particularly to implementation of a "pause and resume" function and a "channel change" function for recording and playing interframe compressed audiovideo data, particularly MPEG data. The invention includes a digital track format and a method for recording one or more sessions from one or more streams of interframe compressed audiovideo data which has been synchronized to a reference clock. The invention adds special "splice point" indicators to recorded video material. The splice point indicators are added either periodically (*e.g.*, by recording a special reference clock) or when a discontinuity occurs in recording audiovideo data streams. Splice point indicators are used to determine the existence of a point of discontinuity in the recorded audiovideo data.

10 The system and method enable pausing and later resuming recording of an audiovideo data stream such that the audiovideo data can be played back with proper resynchronization at each point of discontinuity (a "pause and resume" function). The format and method also allow for recording an abrupt change from one audiovideo data stream to a different audiovideo data stream having a different clock reference, such that the two recorded sequences are spliced together as one continuous recorded sequence that can be played back with resynchronization of the program audiovideo data at each splice point (a "channel change" function).

15 As a consequence of using an added special reference clock as a splice point indicator, the invention also provides random access playback. In addition, the invention permits recording of conventional data in standard storage formats.

20 The details of the preferred embodiment of the invention are set forth in the accompanying drawings and the description below. Once the details of the invention are known, numerous additional innovations and changes will become obvious to one skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of a prior art MPEG decoder.

FIGURE 2 is a timing diagram showing a splice point between two independent MPEG sequences.

5 FIGURE 3 is a block diagram of a record sequence for a channel specific decoder and a record/playback drive in accordance with the invention.

FIGURE 4 is a block diagram of a playback sequence for a channel specific decoder and a record/playback drive in accordance with the invention.

10 FIGURE 5 is a flowchart showing the resynchronization process of the preferred embodiment of the invention.

Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION OF THE INVENTION

Throughout this description, the preferred embodiment and examples shown should be considered as exemplars, rather than as limitations on the invention.

Overview

5 To record MPEG-encoded interframe compressed audiovideo data in real-time without re-encoding the underlying original audiovideo data requires that some provision be made for handling the recording of "splice points". A splice point is defined as a point within recorded multiplexed interframe compressed audiovideo data where the system clock reference changes due to a change in the program material (such as changing channels
10 within a broadcast receiver) or where presentation time stamps differ between reference frames because an input data stream was paused and later resumed. A "session" is recorded audiovideo data ending in a splice point (or an end-of-file, end-of-tape, or similar signal). Recording one input stream of data may result in a plurality of sessions due to pausing and resuming recording; recording two or more input streams of data will
15 result in a plurality of sessions.

FIGURE 2 is a timing diagram showing a splice point between two independent MPEG data streams 10, 11. To prevent malfunction after a splice point, the audio and video decoders must be informed of changes in the system clock reference and presentation time stamps. The video decoder must also have a method of finding a reference picture for
20 resynchronization after a splice point is detected in the recorded data stream. The invention accomplishes these functions by adding special "splice point" indicators to recorded video material. The splice point indicators are added either periodically (e.g., by recording a special reference clock) or when a discontinuity occurs in recording audiovideo data streams. Splice point indicators are used to determine the existence of a
25 point of discontinuity in the recorded audiovideo data.

Recording Process – Time Stamp Embodiment

Because the level of compression varies in MPEG encoded video material, there is no direct relationship between a data stream and video frames. Accordingly, to obtain a reference for the video frames, one embodiment of the invention adds a special time-stamp to the data stream when recording an MPEG-encoded data stream onto media such as tape or disk. For recording purposes, a record/playback drive would be coupled through the system to an MPEG data stream before the MPEG system decoder 2 shown in FIGURE 1. During recording, the remainder of the decoding system 2-5 can remain operational if desired.

More particularly, an otherwise conventional recording record/playback drive (*e.g.*, a DDS or DDS2 4 mm DAT tape drive or recordable CDROM drive) is modified to embody an internal clock reference, preferably operating at about 27 MHz, and a time-stamp clock reference, preferably operating at about 90 KHz. The internal clock reference is loaded with the system clock reference (SCR/PCR) value received from MPEG encoded video material when a receiving decoder (internal to the record/playback drive) has locked to the encoded system clock. This allows the record/playback drive to maintain synchronization with the system clock reference used in encoding the MPEG stream. The time-stamp clock reference provides a time-stamp for recorded data.

MPEG-encoded video is encoded in blocks which are recorded on tracks. In the invention, when recording an MPEG-encoded data stream, each recorded data block contains a subcode group in which the running value of the internal clock reference is stored. The preferred track and block format is described below. In addition, a current value for the time-stamp clock reference is inserted into a "continuity" time-stamp field as a data reference for random access to the tape content. In the preferred embodiment, continuity time-stamp references are written at the track rate for a helical-scan tape recorder, which in one embodiment is every 1/200th of a second. In the preferred embodiment, this rate equals about once per block, but need not occur in every block. In general, the rate for recording continuity time-stamp references should be sufficiently high (at least about once

per second) so as to substantially eliminate perceptible visual defects during recovery from splice point occurrences, as described below.

Using this time stamp approach, during a pause in a program recording session, the internal clock reference and the time-stamp clock reference continue incrementing in the record/playback drive, but are not recorded on the medium. Thus, the track continuity time-stamp references will not be recorded at the pre-defined rate. Accordingly, detecting such "time defects" in the recorded time-stamp references allows for easy identification of a splice point in the recorded data stream.

If the program stream is changed to a different encoded program source, then the receiving channel-specific decoder must again lock to the encoder's reference clock. The record/playback drive must then be reloaded with the SCR/PCR value in the encoded video material to reestablish the internal clock reference and reset the time-stamp clock reference. Different encoded MPEG streams will contain different SCR/PCR values. Hence, when a splice point is encountered on the recording medium, there will be an identifiable time discontinuity that can be detected.

FIGURE 3 is a block diagram of a recording sequence for a channel specific decoder and a record/playback drive in accordance with the invention. A channel specific decoder 20 (comparable to channel specific system decoder 1 in FIGURE 1) having an internal system clock 21 is coupled by a bus or other connection (not shown) to a record/playback drive 22 which has an internal reference clock 23a. A time-stamp clock 23b is derived from the system clock 23a. In the preferred time-stamp embodiment, the system clock 23a generates continuity time-stamps each comprising a 33-bit number that records each tick of a 90-KHz clock.

During recording, a Record command 24 is transmitted from the channel specific decoder 20 to the record/playback drive 22. The Record command 24 is configured to transmit the SCR/PCR for the current decoded program material, which is used to synchronize the

internal reference clock 23a. Normally, once set, the internal reference clock 23a stays synchronized with the current program source. In the preferred embodiment, the Record command 24 also contains a pause/resume flag (*e.g.*, a single toggle bit or a command word) that indicates whether the record/playback drive 22 should physically record onto the medium or otherwise continue to track the system clock 21 without recording.

Recording Process – Event-Driven Splice Point Indicator

In an alternative embodiment, if a splice point occurs due to a pause in recording or a channel change, an “event-driven” splice point indicator can be recorded by the record/playback drive 22 onto the recording medium. The triggering event for recording a splice point indicator due to a pause can be receipt of a Record command 24 with the pause flag set. For a channel change event, the trigger for recording a splice point indicator can be any desired signal characteristic.

In this embodiment, the splice point indicator can simply be a flag (*e.g.*, a single toggle bit or a command word) recorded in some or all of the blocks of audiovideo data on the medium.

Playback Process

For playback purposes, the output of the record/playback drive 22 would be coupled through the system to the MPEG system decoder 2 shown in FIGURE 1. During playback, recorded data tracks are monitored for indications of a splice point. When using an event-driven splice point indicator, simply detecting the indicator is sufficient. When using continuity time-stamp references, non-sequential values in the continuity time-stamp field indicate a splice point. That is, time discontinuities are detected when the continuity time-stamp references are not encountered at the pre-defined output rate of the time-stamp clock 23b, as would occur across a splice point. In the preferred embodiment, since each continuity time-stamp comprises a 33-bit number that records each tick of a 90-KHz clock, simply subtracting each continuity time-stamp from the next occurring time-stamp

and comparing the result to an expected pre-defined value (such as the track rate) will indicate whether a splice point has occurred.

Based on detection of a splice point, the record/playback drive 22 notifies the channel specific decoder 1 to re-synchronize the audio and video streams in the decoders. Further, when using continuity time-stamp references, the invention also provides random access playback, since access to recorded data in the "middle" of a sequence is equivalent to encountering a splice point. That is, a user can move the tape to a desired location and start playback; the record/playback drive 22 will detect a difference in the continuity time-stamp reference from a prior saved state. The record/playback drive 22 will treat such a difference as if a splice point indicator had been encountered, and notifies the channel specific decoder 1 to re-synchronize the entire decoding system. Since the continuity time-stamp references occur relatively frequently, this embodiment of the invention provides the desired random access with little time delay before resynchronization.

FIGURE 4 is a block diagram of a playback sequence for a channel specific decoder 20 and a record/playback drive 22 in accordance with the invention. When the record/playback drive 22 detects a splice point indicator in the video stream, the record/playback drive 22 outputs a "Check Condition" signal 25 to the channel specific decoder 20. The channel specific decoder 20 then responds with a conventional "Request Sense" command 26 to determine the status of the record/playback drive 22. The record/playback drive 22 returns a "Status" packet 27 to indicate a splice point. The Status packet 27 may simply be a flag indicating that a splice point indicator has been encountered, or may include specific information which may be used to determine if the splice point was caused by either a pause condition or a program channel change. For example, the Status packet 27 may include a time stamp value for the session following the splice point indicator, or a Program Identification ("PID") value. The PID is a standard field in all MPEG audiovideo data transport streams that uniquely identifies each data block as belonging to a particular program.

After receipt of the Status packet 27, the channel specific decoder 20 determines if the splice point was caused by either a pause condition or a program channel change. For example, if the current PID value (read from the program stream or from the status packet 27) is the same as the PID value from previously decoded material (the channel specific decoder 20 stores such information from each decoded block), then the splice point indicator was due to a pause condition – the same program was recorded in the sessions before and after the splice point indicator.

In this case, the channel specific decoder 20 can simply adjust the system clock 21 to the SCR/PCR value of the current data blocks or to a time stamp reference provided from the record/playback drive 22. This capability gives the record/playback drive 22 the ability to reset all the parameters in the audio and video decoders and continue playing the new stream (*i.e.*, the next session of audiovideo data after the splice point) with minimal time lapse for the changeover from the prior session.

If the current PID value is different from the previous program material, then the splice point indicator was due to a channel change – different programs were recorded in the sessions before and after the splice point indicator. In this case, a more complex procedure is followed in the preferred embodiment:

- 1) The channel specific decoder 20 needs to determine a new elementary stream ID used in the new program material. An elementary stream ID identifies a particular video or audio stream. The channel specific decoder 20 starts parsing the transport stream of audiovideo data from the record/playback drive 22 for blocks having a new elementary stream ID. The data buffers for the audio and video decoders are flushed. When the new program channel is decoded, the data packets are demultiplexed and passed to the audio and video decoders. The system clock 21 is reset to the value of the PCR value decoded from the new PID transport stream. Alternatively, when using continuity time-stamp references, the time-stamp value for the beginning of the next session can be pre-set to a

value from which an appropriate reset value can be derived, and that reset value can be used to reset the system clock 21.

2) The audio and video decoders are reset with new presentation time stamp values determined from the current elementary streams to be decoded, and continue decoding MPEG information in the data packets from the program channel.

3) At this point the audio and video decoders should be synchronized with the new system clock 21 and begin decoding the new data from the transport program stream. The video decoder looks for a new I-frame to begin video motion, and the audio decoder looks for the next audio block. Once the new reference I-frame is found, the following video data stream can be decoded and viewed. This search process will result in B and P frames being discarded until the new reference I-frame is detected, resulting in a slight delay between the pre-splice point session and the post-splice point session. However, since the playback data is typically buffered in memory, this search process is generally fast enough to minimize or eliminate any visual defects in the displayed video image.

The ability for the record/playback drive 22 to handle both a program pause or a program channel change with the "Check Condition", "Request Sense", "Status" handshake simplifies the re-synchronization process for the channel specific decoder 20.

Other means may be used for determining if the splice point was caused by either a pause condition or a program channel change. For example, various time-stamp fields in the MPEG data stream can be read and compared, or the time-stamp value from a continuity time-stamp field may be used.

FIGURE 5 is a flowchart showing the resynchronization process of the preferred embodiment of the invention, using a continuity time-stamp field as a splice point indicator and PID's for pause/channel change determination. When a discontinuity in the continuity time-stamp field is detected (STEP 400), the record/playback drive 22 issues

a "Check Condition" signal 25 to the channel specific decoder 20 (STEP 402). The channel specific decoder 20 issues a "Request Sense" command 26 (STEP 404). The record/playback drive 22 issues a Status packet 27 (STEP 406). The channel specific decoder 20 then determines if an associated next PID value is the same as or different from a prior saved PID value (STEP 407). If not, the channel specific decoder 20 searches for the next I-frame (STEP 408), and resynchronizes the decoding process using the new I-frame (STEP 410); if so, the channel specific decoder 20 adjusts the system clock 20 to a new SCR/PCR value, as described above (STEP 412).

A similar method is used when the splice point indicator is simply a flag field. Detection of a splice point indicator can be done by any of several circuits or programmed electronics systems. It should be noted that the preferred embodiment does not record splice point indicators (such as the continuity time-stamp values) at precise physical locations on a medium, such that gating circuitry simply detects the presence or absence of a splice point indicator. Rather, the splice point indicator fields preferably are coded within data blocks and conventional block and field parsing techniques and circuitry are used to detect each field as part of the recorded data.

Track and Block Formats

Following is a description of the preferred track format for implementing one embodiment of the invention. A particularly useful aspect of this track format is that it permits recording of conventional data in standard storage formats, such as the well-known DDS and DDS2 data storage formats, and the digital audio tape (DAT) formats. Thus, a record/playback drive implementing the invention with the preferred tape track format provides dual or triple modes: MPEG recording and data and/or audio recording. In the information below, "DVDS" stands for "Digital Video Data Storage", and is a trademark of one implementation of the invention.

Basic Track and Block Parameters:

	Track	= 53 Sync Blocks (132 bytes with 4 byte header)
		= 212 Blocks (8 Blocks Preamble)
	Sync Block	= 1320 Channel Bits (4 byte header + 128 bytes data)
5	Modulation	= 8/10 Encoding
	Main Data	= 48 Sync Blocks
		= 198 Blocks
	Subcode	= 1 Sync Block (for high-speed searching)
	Spacer	= 1 Sync Block (for high-speed searching)
10	Preamble	= 2 Sync Blocks (includes margin for track edge)
	Postamble	= 1 Sync Block

Physical Track Layout:

SYNC BLKS BITS		
2	2640	Preamble
48	63,360	Data + Parity
1	1320	Spacer
1	1320	Subcode
1	1320	Postamble

Coding Patterns:

20	Preamble	= 111 pattern
	Data + Parity	= C1 and C2 codewords
	Postamble	= 111 pattern

Sync Block Format:

5

SYNC + HEADER (4 BYTES)
MAIN DATA (32 BYTES)
MAIN DATA (24 BYTES)
ECC C1 Parity (8 bytes)
MAIN DATA (32 BYTES)
MAIN DATA (24 BYTES)
ECC C1 Parity (8 bytes)

Sync Block Header Format:

10

SYNC
ID
BLOCK NO.
PARITY

15

Sync = 0100010001 for Q = - 1
 = 1100010001 for Q = +1

Format ID = 00 DAT Audio Format
 = 01 for DDS Format
 = 10 for DVDS Format

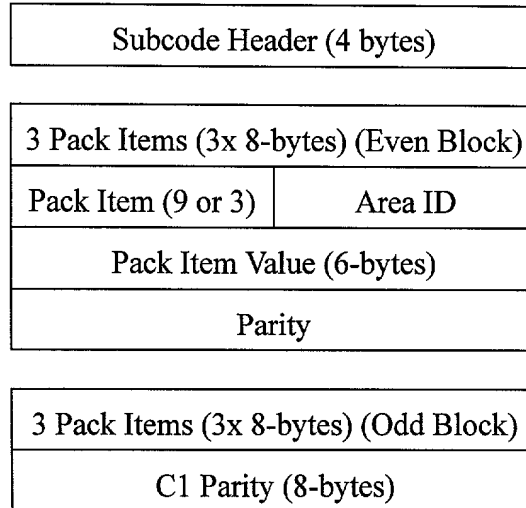
Block = Block Number in Track

20

Parity = ID XOR Block No.

Subcode Byte Format:

5



Repeat Even and Odd Blocks for redundancy.

10

Area ID = 0000 Device Area
 = x001 Reference Area
 = x010 System Area
 = x100 Data Area
 = x101 EOD Area

15

Note: x is set to 1 in a Single Data Space. For two partitions, x=0 for partition 1, x=1 for partition 0.

The Subcode + Header field is covered by C1 and C2 ECC. Subcode Pack Items 1-8 conform to DDS-2 Specification. Pack Item 9 is used to store the 33-bit continuity time-stamp (as 5 bytes in the Pack Item Value field) in the Data Area of the recording medium.

20

Thus, the invention enables pausing and later resuming recording of an audiovideo data stream such that the audiovideo data can be played back with proper resynchronization at each point of discontinuity (a “pause and resume” function). The format and method also allow for recording an abrupt change from one audiovideo data stream to a different audiovideo data stream having a different clock reference, such that the two recorded

sequences are spliced together as one continuous recorded sequence that can be played back with resynchronization of the program audiovideo data at each splice point (a “channel change” function). As a consequence of using an added special reference clock as a splice point indicator, the invention also provides random access playback. In addition, the invention permits recording of conventional data in standard storage formats.

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, while the preferred medium for recording digitally encoded audiovideo data is tape, the invention can be readily adapted for recording such data onto magnetic disks and diskettes, optical recording media, and solid-state recording media. Accordingly, it is to be understood that the invention is not to be limited by the specific illustrated embodiment, but only by the scope of the appended claims.

CLAIMS

What is claimed is:

- 1 1. A method of recording, with a channel change function, and playing back,
2 sessions from multiple digitally encoded, interframe compressed streams of
3 audiovideo data, comprising the steps of:
4 (a) formatting each digitally encoded, interframe compressed stream of
5 audiovideo data for recording;
6 (b) recording each formatted stream on a recording medium as one or more
7 sessions while permitting changes between different formatted streams,
8 wherein the end of each session defines a channel change between
9 different formatted streams;
10 (c) recording on the recording medium one or more splice point indicators
11 providing information sufficient to determine the end of each session;
12 (d) reading each session from the recording medium;
13 (e) applying each session to a synchronizable decoding device;
14 (f) detecting one or more splice point indicators;
15 (g) determining the end of a session based on the information provided by the
16 detected splice point indicators; and
17 (h) re-synchronizing the decoding device to a reference clock value corre-
18 sponding to a next session in response to detection of each session end.
- 1 2. The method of claim 1, wherein each splice point indicator delineates the end of
2 a session.
- 1 3. The method of claim 1, wherein the splice point indicators are continuity time-
2 stamp fields periodically recorded on the recording medium.

- 1 4. The method of claim 3, wherein the reference clock value is derived from at least
2 one continuity time-stamp field.
- 1 5. The method of claim 3, wherein the period of the continuity time-stamp fields
2 permits re-synchronization with essentially no perceptible interruption in decoding
3 of the streams.
- 1 6. The method of claim 5, wherein the period of the continuity time-stamp fields is
2 at least equal to the track rate of a helical scan recording device.
- 1 7. The method of claim 1, wherein the reference clock value is embedded in such
2 next session.
- 1 8. The method of claim 1, wherein the digitally encoded, interframe compressed
2 streams of audiovideo data are MPEG-encoded.
- 1 9. The method of claim 1, wherein the step of re-synchronizing comprises the steps
2 of:
3 (a) issuing a check condition indicating detection of the end of a session;
4 (b) receiving a request sense command; and
5 (c) determining a reference clock value in response to receipt of the request
6 sense command.

- 1 10. A system for recording, with a channel change function, and playing back,
2 sessions from multiple digitally encoded, interframe compressed streams of
3 audiovideo data, comprising:
- 4 (a) a formatting system for formatting each digitally encoded, interframe
5 compressed stream of audiovideo data for recording;
- 6 (b) a recording device for recording each formatted stream on a recording
7 medium as one or more sessions while permitting changes between
8 different formatted streams, wherein the end of each session defines a
9 channel change between different formatted streams, and for recording on
10 the recording medium one or more splice point indicators providing
11 information sufficient to determine the end of each session;
- 12 (c) a media reading device for reading each session from the recording
13 medium and applying each session to a synchronizable decoding device;
- 14 (d) a detector for detecting one or more splice point indicators and determin-
15 ing the end of a session based on the information provided by the detected
16 splice point indicators; and
- 17 (e) a control system for re-synchronizing the decoding device to a reference
18 clock value corresponding to a next session in response to detection of
19 each session end.
- 1 11. The system of claim 10, wherein each splice point indicator delineates the end of
2 a session.
- 1 12. The system of claim 10, wherein the splice point indicators are continuity time-
2 stamp fields periodically recorded on the recording medium.
- 1 13. The system of claim 12, wherein the reference clock value is derived from at least
2 one continuity time-stamp field.

ABSTRACT

5 A "pause and resume" function and a "channel change" function for recording and playing interframe compressed audiovideo data, particularly MPEG data. The invention includes a digital track format and a method for recording one or more sessions from one or more streams of interframe compressed audiovideo data which has been synchronized to a reference clock. The invention adds special "splice point" indicators to recorded video material. The splice point indicators are added either periodically (*e.g.*, by recording a special reference clock) or when a discontinuity occurs in recording audiovideo data streams. Splice point indicators are used to determine the existence of a point of discontinuity in the recorded audiovideo data. The system and method enable pausing and later resuming recording of an audiovideo data stream such that the audiovideo data can be played back with proper resynchronization at each point of discontinuity (the "pause and resume" function). The format and method also allow for recording an abrupt change from one audiovideo data stream to a different audiovideo data stream having a different clock reference, such that the two recorded sequences are spliced together as one continuous recorded sequence that can be played back with resynchronization of the program audiovideo data at each splice point (the "channel change" function). As a consequence of using an added special reference clock as a splice point indicator, the invention also provides random access playback. In addition, the invention permits recording of conventional data in standard storage formats.

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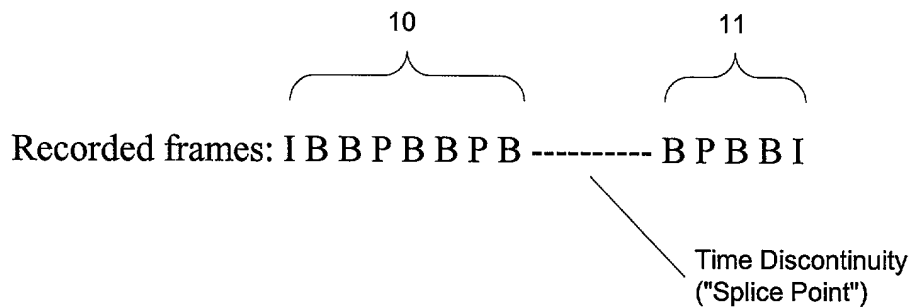


FIG. 2

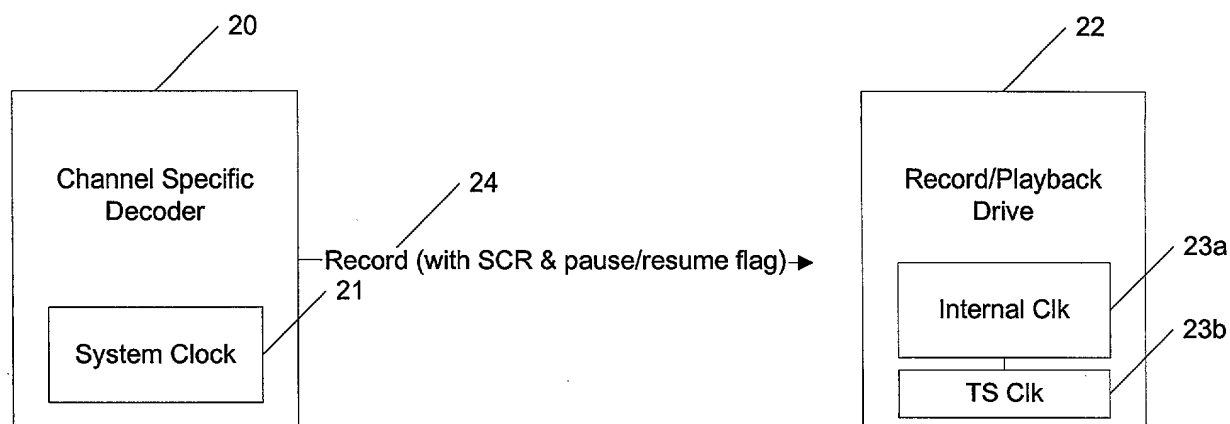


FIG. 3

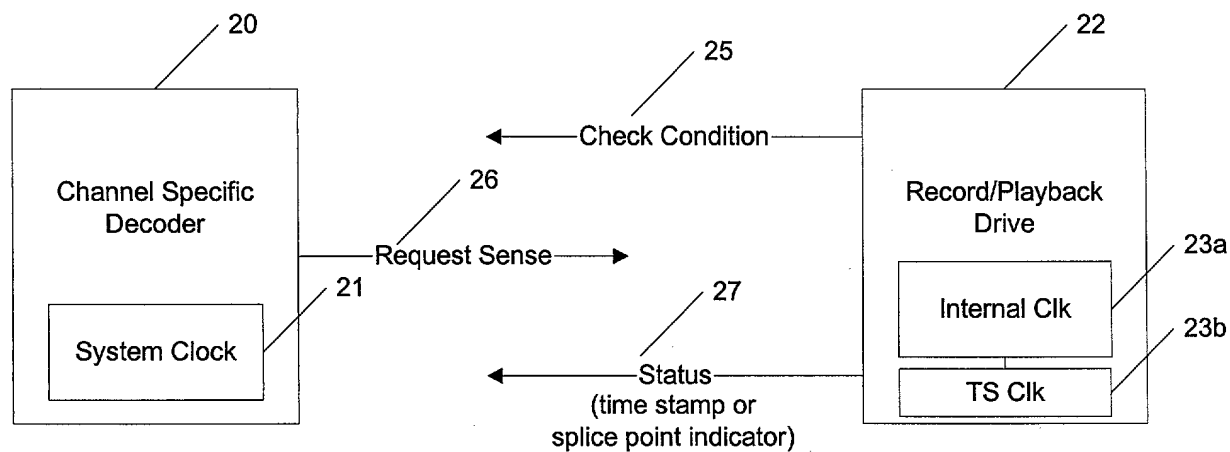


FIG. 4

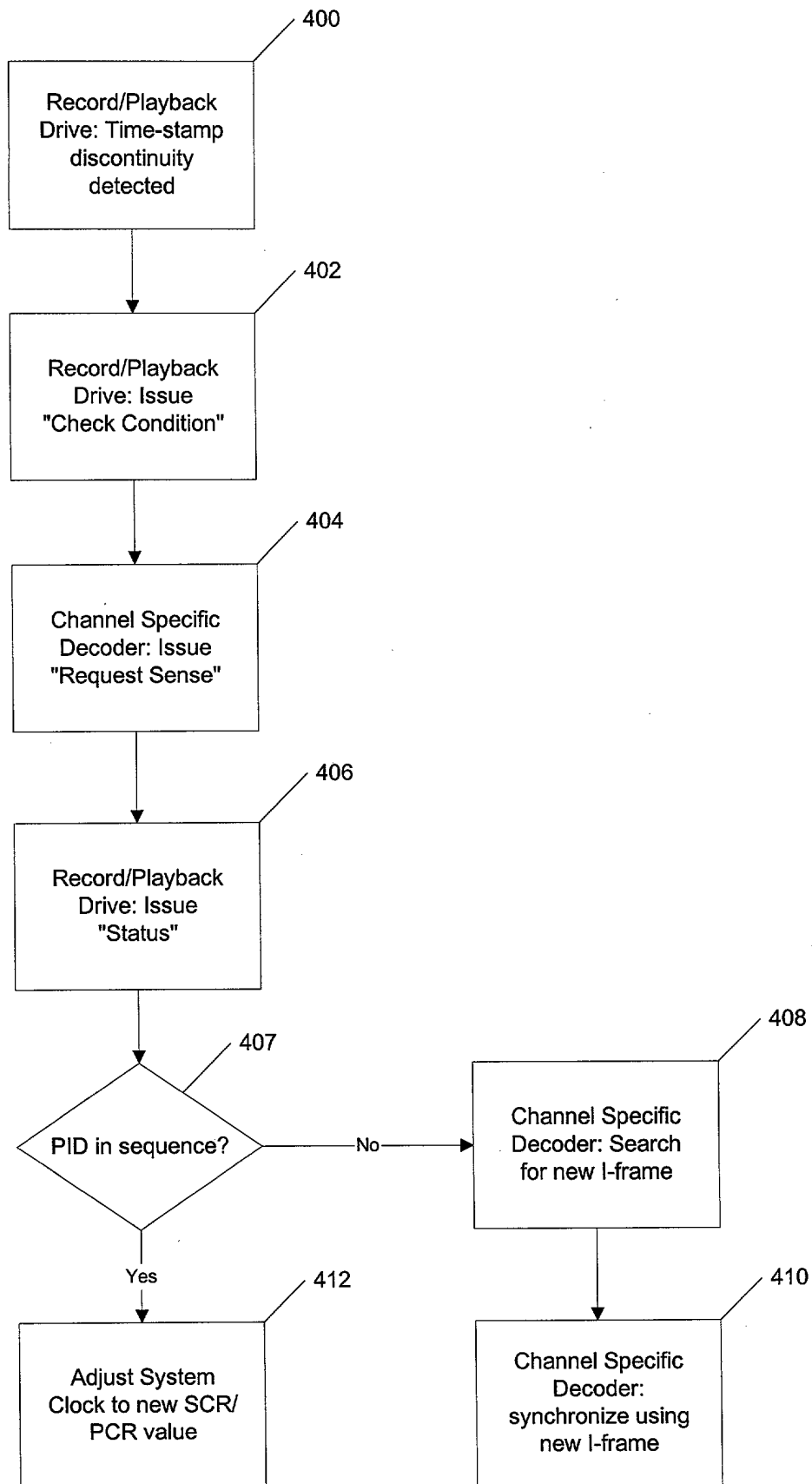


FIG. 5

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled , the specification of which

☐ is attached hereto.

☒ was filed on May 16, 1997 as Application Serial No. 08/858,084.

☐ was described and claimed in PCT International Application No. _____

filed on _____ and as amended under

PCT Article 19 on _____.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: John Land, Reg. No. 29,554, William E. Booth, Reg. No. 28,933; Barry E. Bretschneider, Reg. No. 28,055; John W. Freeman, Reg. No. 29,066; Timothy A. French, Reg. No. 30,175; Alan H. Gordon, Reg. No. 26,168; Scott C. Harris, Reg. No. 32,030; Christopher S. Marchese, Reg. No. 37,177; John B. Pegram, Reg. No. 25,198; Rene D. Tegtmeyer, Reg. No. 33,567; Hans R. Troesch, Reg. No. 36,950; John R. Wetherell, Jr., Reg. No. 31,678; Dorothy P. Whelan, Reg. No. 33,814; Charles C. Winchester, Reg. No. 21,040.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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